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New locality records of *Rhagomys longilingua* Luna & Patterson, 2003 (Rodentia: Cricetidae) in Peru

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Abstract. *Rhagomys longilingua* is one of the rarest sigmodontine rodents of South America, currently known from only 2 localities (4 individuals) in Peru and Bolivia. Here we report 3 additional localities in Peru, one of which extends the geographic distribution range of this species 613 km northeast from the type locality (Suecia, Manu National Park, Cusco department). Potential distribution models showed the presence of *R. longilingua* from Bolivia until Colombia along the eastern slope of the Andes.

Key words. Mountain forest; range extension; potential distribution

Mammalian diversity in Peru is estimated in 555 species, mainly composed by rodents (32.8%) and bats (32.4%), including several endemic species from Peru (Pacheco et al. 2009, Medina et al. 2016, Uturunco & Pacheco 2016, Do Prado & Percequillo 2017, Hurtado & Pacheco 2017). One important area of endemism in Peru is the Humid Eastern Montane Forest on the eastern slope of the Andes (Young 2007). This area forms an ecological and biological system of global importance for the conservation of biodiversity and natural resources; this area has a unique biological diversity, especially among the bryophytes, ferns and fern allies, orchids, melastomes, spiders, frogs, tyrant flycatchers, tanagers, hummingbirds, and rodents (Young & León 1999). Among the taxa of this area is the thomasomyine genus *Rhagomys* (Thomas, 1886), one of the rarest of the subfamily Sigmodontinae, known from a few specimens deposited in museums. Presently, 2 species are recognized, distributed on opposite sides of South America: *R. rufescens* (Thomas, 1886), inhabiting the Atlantic Forest (Brazil), and *R. longilingua* Luna & Patterson, 2003, on the eastern slope of the Andes (Peru and Bolivia) (Luna 2015).

Aiming to contribute on the knowledge on the natural history of *R. longilingua*, we examined material housed at Museum of Natural History of Universidad Nacional de San Agustín (MUSA) and present 3 new localities of this species in Peru. Additionally, we discuss its capture methods, habitat preferences, syntopic species, and distribution of collection localities.

The study of the MUSA collection revealed the existence of 3 specimens assigned to *R. longilingua*, that were collected under the collected authorizations RD. 250-2012-AG-DGFFS-DGEFFS; RJ.054-2012-SERNANP-JEF and RD. 210-2013-MINAGRI-DGFFS/DGEFFS. These are MUSA 13453, adult male, collected at Santa Rita Alta, Chaglla, Huánuco (9°34′31.1″ S, 075°54′11.4″ W; 936 m above sea level [a.s.l.]; datum WGS84; locality 1), on 6 May 2012 by César E. Medina; MUSA 15895, adult male, collected at Urusayhua mountain, Echarate, Cusco (12°41′24.0″ S, 072°39′46.0″ W; 2,155 m a.s.l.; datum WGS84; locality 2), on 6 May 2013 by Kateryn Pino; and MUSA 13856, juvenile male, collected at Wiñaywayna Biological Station, Machu Picchu Historic Sanctuary (13°11′13.5″ S, 072°31′56.2″ W; 2,200 m a.s.l.; datum WGS84; locality 3), on 21 October 2012 by Alexander Pari.

External and cranial measurements of specimens were taken following Luna & Patterson (2003), supplemented by those of Villalpando et al. (2006): head and body length (HBL), tail length (TL), hind foot length (HF), ear length (E), dorsal fur length (DFL), longest mystacial vibrissae length (MVL), longest superciliary vibrissae length (SVL), longest genal vibrissae length (GVL), greatest length of skull (GLS), condylo-incisive length (CIL), rostral length (RL), rostral breadth (RB), orbital fossa length (OFL), nasal length (NL), nasal breadth (NB), least interorbital breadth (LIB), diastema length (DL), bony palate length (BPL), bony palate breadth across first upper molars (BPB), post palatal length (PPL), incisive foramina length (IFL), incisive foramina breadth (IFB), maxillary tooth row length (MTL), palatal bridge breadth (PBB), first upper molar breadth (M1B), zygomatic breadth (ZB), braincase breadth (BB), zygomatic plate breadth (ZPB), incisor depth (ID), braincase height (BH), mesopterygoid fossa breadth (MFB), and Weight (gr.). Color nomenclature follows Ridgway (1912). Terminology of external anatomy and cranial morphology follow Reig (1977), Carleton & Musser (1989), Voss (1988, 1993), Hershkovitz (1993), and Steppan (1995).

The preference habitats and occurrence patterns of *R. longilingua* were investigated using Maximum Entropy niche model

Figures 1–3. Specimen of *Rhagomys longilingua* (MUSA 13453) collected in Santa Rita Alta, Huallaga River, Peru. **1.** External morphology of the living individual. **2.** Diagnostic characters of manus and pes (pads and claws). **3.** Dorsal, ventral and lateral views of cranium and mandible, scale bar equal to 10 mm. (Photos by César E. Medina)

of potential distribution (Phillips et al. 2006), following the protocol suggested by Pearson et al. (2007) and Giménez et al. (2015). Data used included the material examined in this study and previous reports from Bolivia (Villalpando et al. 2006) and Peru (Luna & Patterson 2003). These are the holotype and paratype, both collected at Suecia, a roadside settlement in Manu Biosphere Reserve along the Río Kosñipata, Cusco, Peru (Holotype: 13°06′01.92″ S, 071°34′07.5″ W; 1900 m a.s.l.; datum WGS84; locality 4. Paratype: 13°05′51.2″ S, 071°34′0.8″ W; 2100 m a.s.l.; datum WGS84; locality 5); Maskoitania specimen, collected at left bank Río Alto Madre de Dios, Peru (12°46′18.1″ S, 071°23′07.7″ W; 450 m a.s.l.; datum WGS84; locality 6); Cotapata specimen, collected at Parque Nacional y Area Natural de Manejo Integrado Cotapata, Bolivia (16°12′47.4″ S, 067°53′12.1″ W; 1,860 m a.s.l.; datum WGS84; locality 7).

These 3 MUSA specimens exhibit the following combination of diagnostic characters: the digits II–IV of manus and pes exhibit broad and square-shaped, blunt, callous apical pads, with short and embedded claws; digit I of pes Y-shaped, with a nail; the plantar pads are large and well-defined, fleshy, and flattened, with a heart-shaped callus on the interdigital pads (Figs. 1, 2). The skull exhibits oval-shaped fontanelles about ⅓ the size of the pterygoid processes; the M1 anteromedian crista protruding from the anterolabial conule; the M3 presents only the paracone and protocone; mandibular teeth 2 and 3 (m2 and m3) nearly equal in size and shape, with very conspicuous metaconid, protoconid, posterolophid, and hypoconid elements; all mandibular molars with a posterocrista, a feature shared with other specimens from Peru described by Luna & Patterson (2003) (Fig. 3). Thus, in general, our specimens are quite similar to those described as *R. longilingua* by Luna & Patterson (2003) and also by Villalpando et al. (2006) (Table 1). However, the specimen from Huánuco (MUSA 13453) exhibits slight differences in some characters that could be considered as intraspecific variation in *R. longilingua*, instead variation interspecific between *Rhagomys* species. Among these, one can name: the snout, face, ear base, dorsal surface of feet and underparts are conspicuously orange-colored, differing from the holotype of *R. longilingua* and MUSA 15895, which exhibits a Ochraceous-Orange color (Luna & Patterson 2003); the cranium presents elongated rostrum and braincase, the interorbital region with weakly developed frontal sinuses (resembled to *R. rufescens*), the mesopterygoid fossae is narrow, the postorbital process is delicate, the diastema length is longer (resembled to *R. rufescens*), and tiny coronoid

Table 1. External and cranial measurements (mm.) of *Rhagomys longilingua*. The mean, standard deviation, range (in parentheses) and sample size is included.

	Juvenile Peru MUSA 13856	**Juvenile Bolivia Villalpando et al. (2006)**	**Adult Peru MUSA 13453**	**Adult Peru MUSA 15895**	**Adult Peru Luna & Patterson (2003)**
HBL	52	80	89	92	98 ± 7.00 (90–103) 3
TL	87	75	101	97	97.7 ± 5.69 (93–104) 3
HF	16.1	13	18.1	17.6	19 ± 1.73 (17–20) 3
E	10	9	12.1	13.1	13.9 ± 0.23 (13.6–14) 3
DFL	—	7	9.2	9.0	8 ± 0 (8–8) 2
MVL	—	29	36	33.5	36 ± 1.41 (35-37) 2
SVL	—	19	24	17.5	25.5 ± 0.71 (25-26) 2
GVL	—	14	20	17.3	20.75 ± 1.06 (20-21.5) 2
GLS	22.31	25.34	28.58	27.72	28.33
CIL	19.97	22.99	25.95	25.66	25.52 ± 0.7 (25.02–26.01) 2
RL	5.24	6.92	7.66	6.94	7.7
RB	—	4.44	5.03	5.14	5.03 ± 0.05 (4.99–5.06) 2
OFL	8.29	9.69	10.50	10.52	10.61 ± 0.16 (10.5–10.72) 2
NL	5.91	7.8	8.51	8.84	8.55
NB	2.46	-	2.91	2.73	2.95
LIB	4.98	5.30	5.30	5.45	5.64 ± 0.19 (5.5–5.78) 2
DL	5.66	6.14	7.50	7.7	7.29 ± 0.06 (7.24–7.33) 2
BPL	—	6.09	6.56	6.05	6.76 ± 0.15 (6.65–6.86) 2
BPB	4.59	4.82	4.99	5.09	5.09 ± 0.18 (4.97–5.22) 2
PPL	—	8.46	9.26	9.24	8.79 ± 0.45 (8.47–9.11) 2
IFL	3.42	3.25	3.98	4.45	3.74 ± 0.34 (3.5–3.98) 2
IFB	1.35	1.48	1.49	1.57	1.36 ± 0.11 (1.28–1.44) 2
MTL	3.95	4.23	4.26	4.08	4.41 ± 0.16 (4.29–4.52) 2
PBB	2.00	2.21	2.53	2.55	2.44 ± 0.113 (2.36–2.52) 2
M1B	1.10	1.21	1.15	1.22	1.28 ± 0.03 (1.26–1.3) 2
ZB	12.59	14.71	15.9	15.9	15.87 ± 0.01 (15.86–15.88) 2
BB	—	12.01	13.2	11.24	13.63 ± 0.37 (13.37–13.89) 2
ZPB	2.18	2.75	3.03	2.92	3.13 ± 0.24 (2.96–3.30) 2
ID	1.25	1.47	1.87	1.78	1.83 ± 0.12 (1.74–1.91) 2
BH	8.24	8.52	8.96	9.02	9.16 ± 0.22 (9–9.31) 2
MFB	1.17	1.34	1.46	1.36	1.56 ± 0.23 (1.4–1.72) 2
Weight (g)	—	21	24	25	-

process; whereas the holotype and MUSA 15895 presents short rostrum and voluminous braincase, the interorbital region without developed frontal sinuses, the mesopterygoid fossae are wide, the postorbital process is conspicuous, the diastema length is shorter, and small coronoid process.

The MUSA 13856 specimen was found dead on a path used by tourists, while MUSA 13453 and MUSA 15895 were captured with pitfall traps, in buckets of 20 L with drift fences (Voss & Emmons 1996, Patton et al. 2000) perfuming 90 and 170 buckets-night for Santa Rita Alta and Urusayhua mountain, respectively. The specimens in question were the result of intensive assessments with several capture techniques (snap traps, Sherman and pitfall traps) at localities next to Santa Rita Alta (with a total of 720 traps-night) and Urusayhua mountain (with 1584 traps-night). In all cases, no additional specimens were obtained. Interestingly, 2 of the 3 specimens in the type series of *R. longilingua* were caught in pitfalls traps, despite the employment of Sherman, Museum Special, Victor, and Tomahawk traps at locality type (Luna & Patterson 2003), however the third specimen was caught in a museum special trap, set 1.5 m above ground in "caña brava" (patches of bamboo, genus *Chusquea* Kunth).

The specimens MUSA 13453 and 15895 were captured together 6 small mammal species in Santa Rita Alta and 8 species in Urusayhua mountain, respectively (Table 2). *Neacomys spinosus* was the most abundant species in Santa Rita Alta (0.11 individuals by each 10 buckets-night), and *Akodon aerosus* and *Microryzomys minutus* were in Urusayhua mountain (0.24 individuals). *Rhagomys longilingua* were inside the group species with lower relative abundances in your localities (Table 2).

Dunnum et al. (2008) maintained that the lack of records of species like *Rhagomys* and other small mammals might reflect low sampling effort and inadequate methods; however, we agree with Percequillo et al. (2011) that the genus probably occurs at low abundance and low densities throughout its range, and also with Villalpando et al. (2006), who suggested that pitfall traps are the best capture method for this genus.

The specimen MUSA 13453 was captured near a dry ravine inside a disturbed mountain forest, cleared for agriculture 5 years earlier but regenerating today, surrounded of large areas with farming of manioc, maize and banana tree. The individual MUSA 13856 was found next to one of the most notable tourism spots in the world (Machu Picchu), inside a cloud forest disturbed by intensive tourism. The specimen MUSA 15895 was captured near a dry ravine inside an undisturbed cloud forest. These records suggest that *R. longilingua* apparently is a tolerant species, inhabiting areas with different level of perturbation. Luna & Patterson (2003) described an insectivorous diet for *R. longilingua* using stomach content analysis.

The specimen MUSA 13856 increases the upper elevational limit of *R. longilingua* to 2200 m a.s.l., meanwhile its lower limit it maintained in 450 m a.s.l. (Luna & Patterson 2003). This range of distribution suggest that *R. longilingua* inhabits various forest types, such as Montane humid pluviseasonal forest, Montane pluvial forest, Lower montane humid pluviseasonal forest, Lower montane pluvial forest and palm grove, all of the Yungas, as well as Southwestern Amazon subandean evergreen forest and Southwestern Amazon piedmont forest (NatureServe 2009).

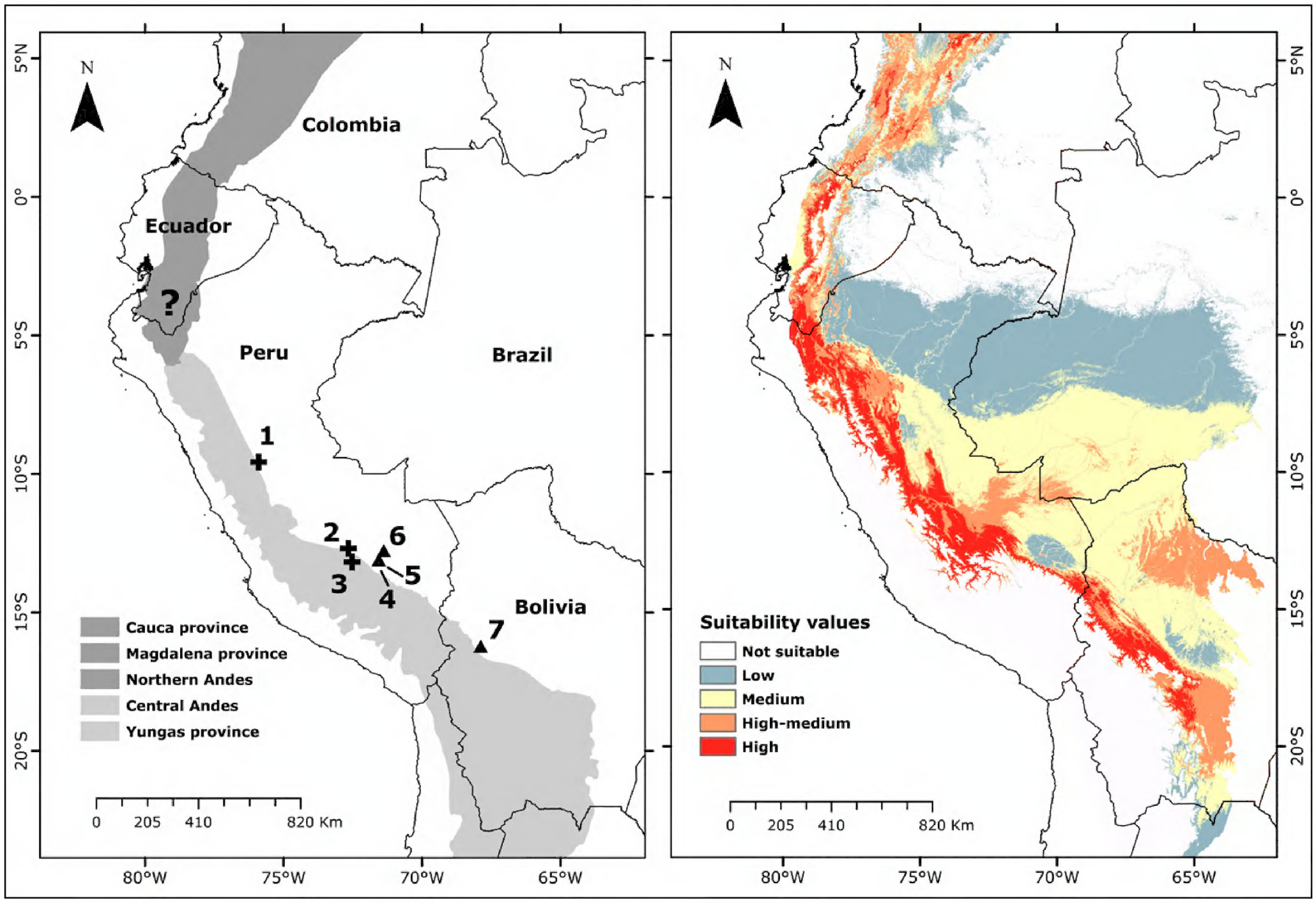
The specimen MUSA 13453 represents the northernmost record of *R. longilingua*, extending the species' range 613 km northeast of the type locality, Manu Biosphere Reserve along Rio Kosñipata (Luna & Patterson 2003) (Fig. 4).

The 7 known localities for *R. longilingua* suggest a continuous distribution along the eastern slope of the Andes, from northern Bolivia to central Peru (Fig. 5). In contrast, the model inferred high suitability for the montane forests from Bolivia, Colombia, Ecuador and Peru (predictive values > 50%; P value < 0.05), being the altitude, minimum temperature of the coldest month, precipitation of the coldest quarter, and mean of monthly temperature range the most important variables for the model (66.4% of the variation in inferred suitability). These variables reveal the affinity of *R. longilingua* by inhabit on tropical montane cloud forests from Northern and Central Andes.

The predicted presence of *R. longilingua* in Colombia is notable, which could be interpreted as a mistake of the model. However, we support this distribution range due to one specimen of *Rhagomys* sp. recently collected in the Zamora Region (Ecuador), which was misidentified as *Neacomys spinosus* (Narváez et al. 2012: plates 74 and 75). We obtained additional photos of that specimen, and it seems to be *R. longilingua* due to the following external characters: texture of the pelage markedly spiny, plantar pads on hind feet well developed, all digits of the manus and pes have broad, squared-shaped, blunt, and callous tips and deep transversal grooves, as well as a nail in the hallux.

Table 2. Relative abundance of small mammal species captured in Santa Rita Alta (Huánuco) and Urusayhua mountain (Cusco).

Order	Species	Santa Rita Alta	Urusayhua mountain
Didelphimorphia	*Marmosops noctivagus* (Tschudi, 1845)	0.22	0.06
	Monodelphis sp. Burnett, 1830	0.22	
	Monodelphis peruviana (Osgood, 1913)		0.18
Rodentia	*Akodon aerosus* Thomas, 1913		0.24
	Euryoryzomys macconnelli (Thomas, 1910)	0.11	
	Hylaeamys yunganus (Thomas, 1902)	0.11	
	Microryzomys minutus (Tomes, 1860)		0.24
	Neacomys spinosus (Thomas, 1882)	0.67	
	Neacomys musseri Patton, da Silva & Malcolm, 2000		0.06
	Oecomys bicolor (Tomes, 1860)	0.11	
	Oligoryzomys destructor (Tschudi, 1844)		0.12
	Rhagomys longilingua Luna & Patterson, 2003	0.11	0.06
	Thomasomys notatus Thomas, 1917		0.18



Figures 4, 5. Distribution maps of *Rhagomys longilingua*. **4.** Updated distribution, new records are denoted with crosses and previous records with triangles (numbers are keyed to localities mentioned in the text). Record of *Rhagomys sp.* from Ecuador (NARVÁEZ et al. 2012) is denoted with question mark. Northern and Central Andes follow JOSSE et al. (2009). **5.** Potential distribution based on Maxent model. Suitability values of 100–51 (high prediction), 50–26 (high-medium), 25–11 (medium), 10–2 (low), and 1–0 (null).

Interestingly, *Rhagomys* sp. inhabit areas north of the Huancabamba Depression (Northern Andes); meanwhile, the known specimens of *R. longilingua* occur at south of the Depression (Central Andes) (JOSSE et al. 2009). Considering that some scientists have suggested that the Huancabamba Depression in northern Peru (i.e., the partial interruption of the Andean chain by the Rio Chamaya drainage system) represents a major biogeographical barrier to montane taxa (VUILLEUMIER 1968, WEIGEND 2002), it would not be surprising if this individual represents an undescribed taxonomic entity.

All material here supports the hypothesis that *Rhagomys* is widespread in South America (LUNA & PATTERSON 2003, PERCEQUILLO et al. 2004, 2011, PINHEIRO et al. 2004). The genus may have originated in either the premontane forests region of the northern Andes, or in the lowland forests of the western Amazonian basin (VILLALPANDO et al. 2006, STEINER-SOUZA et al. 2008; PERCEQUILLO et al. 2011). However, cytogenetic and molecular studies are necessary to resolve the phylogenetic relationship of *Rhagomys* and to determine whether *R. longilingua* as presently understood is indeed a species complex.

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